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BY FEDERAL EXPRESS

November 4, 1993

93-225

Mr. William F. Caton
Office of the Secretary
Federal Communications Commission
1919 M Street, N.W.
Washington, DC 20554

Dear Mr. Caton:

On behalf of Hammett & Edison, Inc., Consulting Engineers, three copies of the enclosed Comments to the July 23, 1993, Notice of Inquiry in Mass Media Docket ~~93-254~~ are hereby submitted.

Sincerely yours,

William F. Hammett

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Enclosures (3)

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Before the
Federal Communications Commission
Washington, DC 20554

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In the matter of

Amendment of Part 73 of the Commission's Rules to Clarify the Definition and Measurement of Aural Modulation Limits in the Broadcast Services	)))))	MM Docket No. ~~93-155~~

To: The Commission

Comments of Hammett & Edison, Inc., Consulting Engineers, Concerning the Notice of Inquiry Adopted July 23, 1993.

1. Hammett & Edison, Inc., Consulting Engineers, a firm that provides engineering services to the broadcasting industry, hereby respectfully submits its timely-filed comments in the above-captioned Notice of Inquiry (NOI) relating to modulation.

2. Hammett & Edison, Inc. supports retaining modulation limits, with certain needed clarifications, for all FM and TV (aural) broadcast stations until such time as thorough testing might provide a bandwidth measurement criteria that addresses our allocation, receiver interoperability, and emerging-technology concerns, or until conventional analog modulation techniques have been supplanted by digital or other methods.

3. Limits imposed on modulation serve two functions. First, they limit the effective bandwidth of the emission and provide an alternative metric to bandwidth measurement that requires equipment that is relatively simple, convenient, and inexpensive. Second, they ensure reasonable consistency between broadcasters, thus providing *de facto* standards for receiver design.

Definition of Overmodulation

4. As the Commission is fully aware, during the 1983 technical deregulation of the broadcast industry, the rules requiring radio and television stations to have an FCC type-approved aural

modulation monitor were excised[1]. Nonetheless, licensees were not relieved of their obligation to ensure that they did not modulate their transmitters in excess of the limits permitted by the Rules. Unfortunately, the definition of this limit became ambiguous, with the removal of the specific technical parameters by which modulation monitors were calibrated. Competitive marketplace forces mandate that stations run the maximum amount of modulation permitted. Under the present rules, operating at the maximum value could potentially result in a Notice of Apparent Liability being issued by the Commission.

5. The determination of whether a broadcaster is exceeding the modulation limits specified in the Rules requires an unambiguous definition of those limits. For AM broadcast stations, those limits are unambiguously defined in Sections 73.14 and 73.1570 of the Rules.

6. For FM and TV (aural) broadcast stations, clarification or refinement of the definition of peak modulation (or equivalently, frequency deviation) is required. The simplest refinement would be to remove the ambiguous phrase "on peaks of frequent recurrence" from the definitions in Section 73.1570. This change would harmonize the Commission's definition with that of International Radio Consultative Committee (CCIR, now the Radio Communications Bureau) Recommendation 641[2] and with the U.S.-Mexico Agreement on FM Broadcasting[3]. Both of these documents specify 75 kHz as the maximum permissible deviation under any condition. The Commission could specify additional deviation up to a maximum of 82.5 kHz for FM broadcast stations, under those conditions where greater deviation is presently permitted under the Rules.

FM Modulation Calculation and Measurement

7. The modulation index determines the energy-frequency distribution of a FM emission. This index depends both on the deviation and modulating frequency. Although not explicit in the Rules, a modulation index of five[4] is the standard for U. S. FM broadcasting. By defining the frequency

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1 FCC, A Re-examination of Technical Regulations, Gen. Docket 83-114 (Adopted November 8, 1984).

2 ITU, Recommendations and Reports of the CCIR (Geneva: 1986), Volume X - Part 1, p. 215.

3 FCC, Agreement between The United States of America and The United Mexican States Concerning Frequency Modulation Broadcasting in the 88 to 108 MHz Band (Washington, DC: 1972) Part III, Article 4, Section C (2).

4 FCC, Side Band Components of an FM Carrier TRR Report 6.1.13 (Washington, DC: FCC, 1953).

deviation to be 75 kHz for 100% modulation and limiting the maximum modulation to 110% (82.5 kHz deviation) for FM broadcast stations with subsidiary communications subcarriers, continued support of the existing 200 kHz channelization and frequency allotment plan is achieved. The modulation index, represented by the Greek letter ß, is defined as follows:

$$ß = \Delta f / f_m$$

where Δf is the amount of deviation away from the carrier frequency and f_m is the modulating frequency.

8. For simple sinusoidal modulation, the occupied bandwidth of the resultant FM signal can be calculated to any degree of accuracy by summing the Bessel coefficients for each of the harmonic components away from the carrier frequency. For cases involving more complex, but deterministic, combinations of sinusoids, it is possible to evaluate the Bessel coefficients for each of the component sinusoids, and then of each of the possible combinations (sums and differences) of the component sinusoids. This approach can be very laborious[5], but there are computer programs available to solve the necessary equations. We understand that the comments of the Society of Broadcast Engineers, Incorporated (SBE) identify two such programs. Fortunately, it can be shown that only the lowest order combinations are required to represent the spectrum containing over 99.9% of the energy[6].

9. The program material aired by FM broadcast stations typically can be represented by weighted, band-limited noise when integrated over a sufficiently long time. This noise would occupy a continuous spectrum from roughly 50 to 15,000 Hertz, but the power spectrum would not be constant across this band. For speech-only programming, one would expect increasing power up to around 200 Hz, then decreasing power beyond about 1200 Hertz, to account for the typical formants found in the human voice[7]. Since this shaped noise can be represented by a signal with a symmetric probability density function, the program material can be represented in a similar statistical way. The mean-square voltage density (*i.e.*, power spectral density) of an FM signal is equivalent to the probability density function, p, and is proportional to:

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5 L.J. Giacoletto, "Generalized Theory of Multitone Amplitude and Frequency Modulation," Proc. I.R.E., July, 1947, pp. 680-693.

6 *ibid.*

7 Lawrence E. Kinsler, *et al.*, Fundamentals of Acoustics (New York: John Wiley & Sons, 1982), p. 275.

$$p(f) \alpha \frac{p[1/\Delta f\,(f - fc)] + p[1/\Delta f\,(f + fc)]}{\Delta f}$$

where f is the instantaneous frequency, f_c is the carrier frequency, and Δf is the peak deviation.

10. If deviation peaks beyond 75 kHz or 82.5 kHz are to be permitted, a more accurate way of representing the RF power spectrum or frequency distribution of FM and TV (aural) broadcast stations would be to utilize statistical techniques[8]. We do not believe that equipment capable of determining compliance with a statistically-based modulation limit is presently available, but it is certainly within the capability of computers of even modest performance and would become commercially available if the Commission were to adopt such a limit.

Emission Limitations

11. The RF emission measurement procedure for AM broadcast stations, specified in Section 73.44 of the Rules, is unambiguous. It defines the specific equipment and set-up to be used and could be employed as a model for the development of a similar procedure for FM and TV (aural) stations. Such a clarification would be desirable as a complement to a definitive modulation limit.

12. The modulation limits and emission limitations "mask" presently specified in the Rules serve as a guide to receiver manufacturers and, when combined with the allocation criteria specified in the Rules, provide interference protection to broadcast stations. Modification of these emission limitations should be considered only with great care, since the FM and TV allocation structures could be affected with unanticipated and possibly disastrous results to U.S. broadcasters.

13. Allowing FM broadcast stations the option of exclusively using a bandwidth mask to determine compliance with the Rules, without reliance on modulation limits, should be considered dependent on preserving receiver interoperability. For example, it seems likely that, even though computer simulation or laboratory measurements might show adherence to a seemingly-restrictive bandwidth mask, the maximum deviation of an FM broadcast signal still could be increased significantly, causing a large number of consumer receivers to distort or otherwise malfunction. Of course, such an

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[8] ITU, *op. cit.*, pp. 218-223.

increase would raise the received distortion of program material but, for some broadcasters, the potential of dramatically increasing loudness might be worth the additional distortion.

14. Various plans have been well publicized to make use of the under-utilized spectrum beyond ±120 kHz of the center frequency of an FM broadcast station. Proponents of certain in-band Digital Audio Broadcasting (DAB) techniques have shown that constructive use of this spectrum can be made without deleterious effects to conventional FM broadcasting. Future developments in the superposition of digital or other forms of modulation on the conventional analog FM signal would also likely need to take advantage of this spectrum. We therefore believe that any tightening of the existing mask may have detrimental effects on such developments of more efficient use of the FM broadcast spectrum.

15. In summary, Hammett & Edison believes that prudence requires the Commission to retain modulation limits in preference to establishment of a more-restrictive FM occupied bandwidth mask until such time as it can be shown that the use of an occupied bandwidth mask would not negatively impact receiver interoperability or emerging in-band digital broadcasting technologies. In any event, the Commission should certainly remove the ambiguity on the definition of peak modulation for FM systems and the resulting discrepancies between current methods of peak modulation measurement. Clearly defined and strictly enforced modulation limits would best serve the interests of broadcasters, receiver manufacturers, and the listening public.

Respectfully submitted,

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November 4, 1993